Dissection of the Spiny Dogfish Shark – *Squalus acanthias*
Biology 110 – Penn State New Kensington
(D. Sillman - adapted from 'Laboratory Studies in Integrated Zoology' by Hickman and Hickman)

Classification
Phylum Chordata, Subphylum Vertebrata, Class Chondrichthyes (cartilagenous fishes)

The class Chondrichthyes includes the sharks, rays, skates and chimaeras and is characterized in part by having a skeleton made of cartilage instead of bone. Most fish belong to the class Osteichthyes (bony fish – skeletons made of bone). The sharks are very generalized vertebrates and are large enough to dissect fairly easily, making them a popular choice for introductory vertebrate dissection. Dogfish sharks are marine and are common along both the Atlantic and Pacific coasts. They grow to about 1 m in length, live 25-30 years, and are omnivorous (eating both plant and animal matter).

External structure **(Refer to Figures 1 and 2 on p. 5)**

The body is divided into the **head** (anterior to the pectoral fins), **trunk** (from pectoral fins to pelvic fins), and **tail**. The fins include a pair of **pectoral fins** (anterior), which control changes in directions during swimming; a pair of **pelvic fins**, which serve as stabilizers and which in the male are modified to form claspers used in copulation; two median **dorsal fins**, which also serve as stabilizers; and an asymmetrical **caudal (tail) fin**. The *spiny* dogfish is so named for a pair of spines immediately anterior to each dorsal fin. These spines are often removed from dissection specimens as they are mildly poisonous!

Identify the **mouth** with its rows of teeth (modified placoid scales), which are adapted for cutting and shearing; two ventral **nostrils**, which lead to olfactory sacs and which are equipped with folds of skin that allow continual in-and-out movement of water; and the lateral **eyes**, which lack movable eyelids but have folds of skin that cover the outer margin of the eyeballs. The part of the head anterior to the eyes is called the **snout**. A pair of dorsal **spiracles** posterior to the eyes are modified gill slits that open into the pharynx. They can be closed by folds of skin during part of the respiratory cycle to prevent the escape of water. Five pairs of **external gill slits** are the external openings of the **gill chambers**. Insert a probe into one of the slits and notice the angle of the gill chamber. The pharynx is the region in back of the mouth into which the gill slits and spiracles open. A **lateral line,** appearing as a white line on each side of the trunk, represents a row of minute, mucus-filled sensory pores used to detect differences in the velocity of surrounding water currents, and thus to detect the presence of other animals, even in the dark. Note the **cloacal opening** between the pelvic fins. This is a common exit for digestive and urinary waste, sperm from the male reproductive system and, in the female, the passageway through which the pups are born. "Cloaca" comes from the Latin word for sewer.

The skin consists of an outer layer of epidermis covering a much thicker layer of dermis densely packed with fibrous connective tissue. The leathery skin is covered with **placoid scales**. Each scale has a wide base embedded in the skin and a spine that projects from the surface pointing posteriorly. Run your hand over the skin, first from heat to tail, then back the other way to feel the projecting spines of the scales. These are very different than the scales of bony fishes. Placoid scales are actually similar in structure to teeth. The dark dorsal and light ventral coloration of the skin makes the shark less conspicuous (Why? Think where the natural light is coming from…).

Internal structure (Refer to Figures 3 – 7)

Open the coelomic cavity by extending the mid-ventral incision caudally to just in front of the cloacal opening and cranially to just below the mouth. You will need to cut through the cartilage of the pectoral girdle between the pectoral fins. Now, make transverse cuts caudal to the pectoral fins and cranial to the pelvic fins to open the posterior part of the coelomic cavity. Rinse out the body cavity.

The body cavity is lined with **parietal peritoneum**, a shiny membrane tightly adhering to the inner surface of the cavity. Each organ in the body cavity is also covered with a tightly adhering membrane, called **visceral peritoneum**. These peritoneal membranes come together to form the double-membraned **dorsal mesentery** that supports the digestive tract.

Digestive system
Identify the large **liver** which is very rich in oil for energy storage. The liver has two large lobes and a small median lobe. Note the elongated greenish gallbladder, embedded in the median lobe. Move the liver aside to see the large **esophagus**, which leads from the pharynx to the J-shaped **stomach.** Follow the stomach around the curve of the 'J' and locate a narrowing point; this is the **pyloric valve**, a muscular constriction between the stomach and the **duodenum** (the first part of the intestine). The pyloric valve controls the passage of food out of the stomach. Make a slit in the wall of the stomach and extend the cut upward into the esophagus. Remove and examine the contents of the stomach and then rinse it out to allow you to view the **rugae** (folds) within the stomach and the **papillae** lining the inner wall of the esophagus. What function do you think these inner structures serve?

Next, find the 2 portions of the **pancreas**. A small portion sits partially on the ventral surface of the duodenum, while a slender dorsal portion extends posteriorly to the large, triangular **spleen** (not a part of the digestive system). Finally, identify the **valvular intestine**, a short, wide tube which contains a **spiral valve**. Make a slit in the wall of the valvular intestine and open the tube enough to view the internal spiral valve. The spiral valve increases the surface area for absorption of nutrients in this very short intestinal tube. (How does the human intestine increase surface area?). The valvular intestine narrows into the colon, which empties into the **cloaca**. Locate the long, thin **rectal gland**, dorsal to the colon. The rectal gland concentrates and excretes salt, important in osmoregulation.

Urogenital system
Although the excretory and reproductive systems have very different functions, they are closely associated structurally, and so are studied together. The **kidneys** are long and narrow and lie behind the parietal peritoneum (human kidneys are also 'retroperitoneal'), one on each side of the midline of the dorsal body wall. These long, narrow kidneys extend from the pectoral girdle to the cloaca. Running along the surface of each kidney is a convoluted **wolffian duct** which (in females) carries the urine formed in the kidney to the **renal papilla** inside the cloaca for excretion. Open the cloaca to see the renal papilla.

Male – Locate the **testes** along the dorsal body wall, one on each side of the esophagus. A number of very fine tubules (too small to see with the naked eye) connect each testis to the wolffian duct (also called sperm duct in males). Sperm is formed in the testes and then travels through the wolffian ducts to sperm sacs which empty via the renal papilla into the cloaca. Thus the wolffian duct in males carries sperm, not urine. Accessory urinary ducts receive the urine formed in the kidneys and transports it to the renal papilla and into the cloaca. The male pelvic fins include modified structures called **claspers**. The claspers direct the sperm and seminal fluid from the cloaca of the male to the cloaca of the female during copulation.

Female - A pair of **ovaries** lies against the dorsal body wall, one on each side of the esophagus. In mature specimens, enlarged ova may form several rounded projections on the surface of the ovaries. A pair of oviducts travel next to each kidney along the dorsal length of the body cavity and enlarge at the caudal end to form the uterus. At the cranial end, the oviducts join and have a common opening called the ostium (the uterus and ostium are difficult to see in immature specimens). When an egg ruptures through the surface of the ovary into the abdominal cavity, it is swept into the ostium and then into one of the oviducts. Fertilization occurs inside the oviducts and the fertilized eggs develop into embryos in the uterus. Amazingly, dogfish shark embryos take almost 2 years to develop within the uterus and are born live, exiting the uterus through the cloaca. This type of development is termed 'ovoviviparous', meaning the young are born live, but during gestation receive nutrients mainly from the egg, not directly from the mother's uterus. Human development is 'viviparous' – young are born alive and receive nutrients via the mother's uterus.

Circulatory system - Heart

The heart lies in the pericardial cavity, cranial to the pectoral fins and the cartilagenous pectoral girdle. The human circulatory system consists of 2 separate circulation: the pulmonary circulation, which pumps deoxygenated blood to the lungs and then receives the oxygenated blood back from the lungs and the systemic circulation, which pumps oxygenated blood to the entire body and receives the deoxygenated blood back from the body. The shark has only a single circulation and the heart pumps only deoxygenated blood through as follows:

- Deoxygenated blood returns to the heart via veins and enters the thin-walled, flat **sinus venosus** (you will need to lift the main portion of the heart to view this structure)
- Blood flows from the sinus venosus into the **atrium**, which is a thin-walled chamber with 2 lobes bulging out to the sides. The atrium also is best seen by lifting the main portion of the heart.
- Blood flows next into the most obvious and muscular chamber, the **ventricle**. The atrium and ventricle constitute the classic '2 chambered fish heart'.
- The ventricle contracts to push the blood into the **conus arteriosus**, a muscular tube which exits the ventricle cranially and narrows into the **ventral aorta**. The ventral aorta is the main ventral blood vessel in the head. Branches from the ventral aorta, the **afferent branchial arteries**, carry the deoxygenated blood to the gills, where oxygenation of the blood occurs.

Circulatory system - Arteries

As mentioned above, the **ventral aorta** and the **afferent branchial arteries** transport the deoxygenated blood from the heart to the gills, for oxygenation.

To view these vessels you must remove a large amount of muscle tissue from the ventral portion of the head up to the lower jaw. It is best to do this dissection by carefully following the ventral aorta forward as you remove the muscle tissue. Do this carefully so as not to damage the underlying blood vessels. As you follow the ventral aorta forward, look for vessels branching off to the sides – these are the afferent branchial arteries, which deliver the deoxygenated blood to the gills. Efferent branchial arteries (difficult to dissect, so we will not see these) return the newly oxygenated blood to other blood vessels which deliver the oxygenated blood to all parts of the body.

You can easily locate two of the vessels which deliver blood to the lower part of the body – the **dorsal aorta** and the **celiac artery**. Both these vessels have been injected with red plastic to make them easier to observe. The dorsal aorta travels the length of the body and can be located between the kidneys. Once you have found the dorsal aorta, look for the celiac artery - a prominent branch from the aorta which travels via the mesentery toward the organs in the abdominal cavity.

Circulatory system - Veins

Look for a prominent yellow-injected vessel running in the mesenteries from the intestines to the liver – this is the **hepatic portal vein**. This vein gathers blood chiefly from the digestive system and delivers this nutrient rich blood to the liver, where the carbohydrates are converted and stored in liver cells for future energy needs. We will not locate any other veins, however be aware that the entire body is served by a system of veins which return the deoxygenated blood to the heart.

Respiratory system

In the sharks, water enters through both the mouth and the spiracles and is forced laterally through the five pairs of gills and exits through the five pairs of **external gill slits**. On one side, separate the gill units by cutting dorsally and ventrally from the corners of each gill slit. Visualize the **gill chamber** within which the gill is bathed by water rich in oxygen. Continue to cut between adjacent gills and extract a portion of a gill to examine.

The incomplete rings of heavy cartilage supporting the gills and protecting the afferent and efferent branchial arteries are called **gill arches.** Short spikelike projections extending medially from the gill arches are the **gill rakers,** which filter the respiratory water and direct food toward the esophagus. Examine the soft, brown tissue comprising the **gill filaments** – the site of actual gas exchange. The pink color you see within this tissue is due to the large number of capillaries. Oxygen absorbed from the water diffuses into blood within these capillaries, just as oxygen diffuses into capillaries in the alveoli of human lungs. In addition, carbon dioxide diffuses out of the blood and into the water within the gill chambers, where it exits through the external gill slits.

Clean-up Procedure

- Place any small bits of tissue that are not to be saved in the biohazard boxes. **Absolutely no preserved tissue can be placed in the regular trash.**
- Put your specimen in the plastic bags provided and close with a rubber band. Put your bagged specimen in the container available.
- Place all dirty dissection tools in the soaking bins by the sinks in the lab.
- Use the spray cleanser and paper towels to clean your dissection tray. Dry your tray thoroughly and stack with other clean trays.
- Use the spray cleanser to and paper towels to clean the tabletop in your work area.

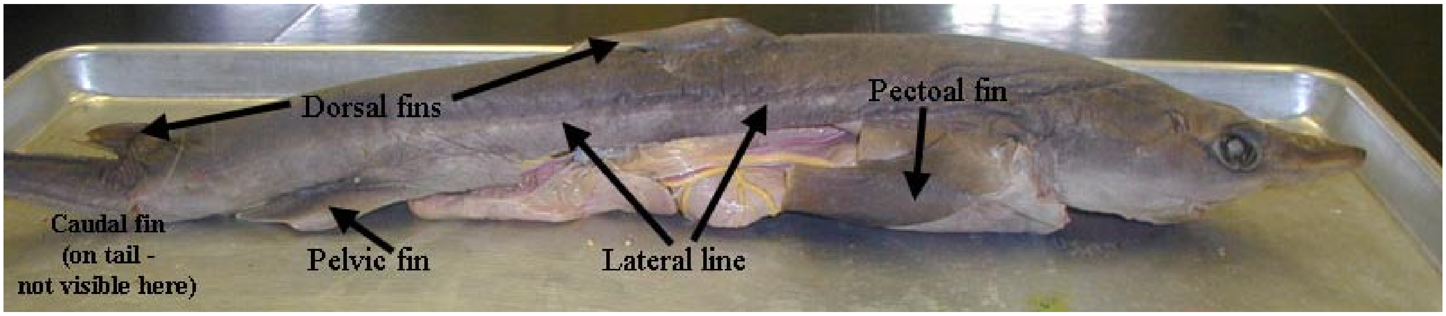

Figure I – External Structures of the Spiny Dogfish Shark

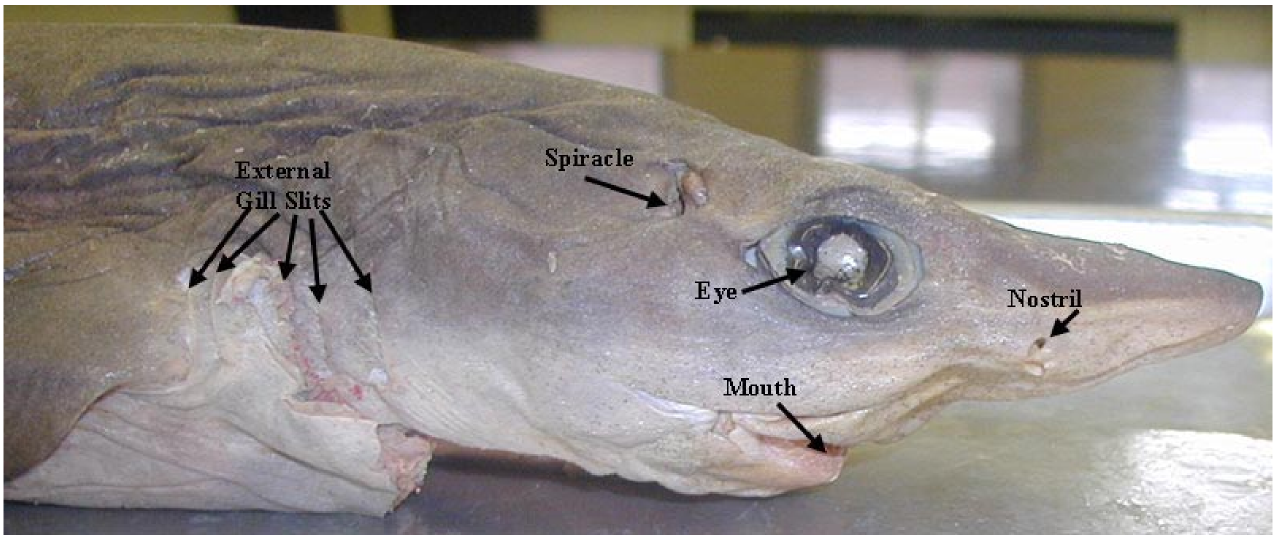

Figure 2 – Additional External Structures of the Spiny Dogfish Shark

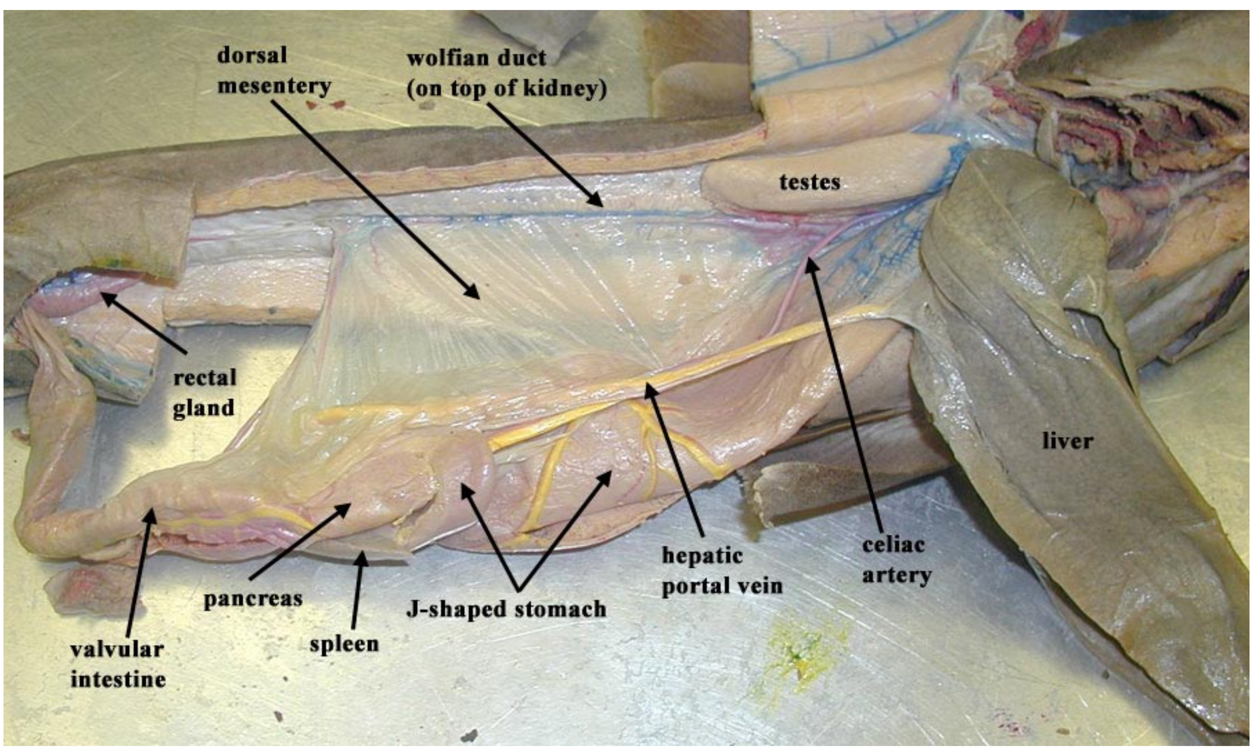

Figure 3 – Internal Structures of the Spiny Dogfish Shark

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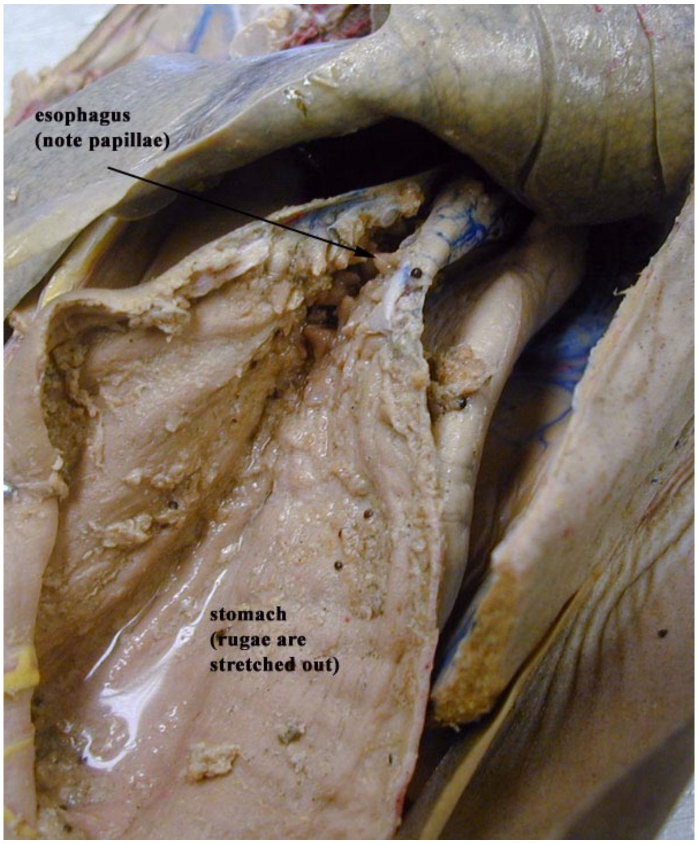

Figure 4 – Internal View of the esophagus and stomach of the Spiny Dogfish Shark

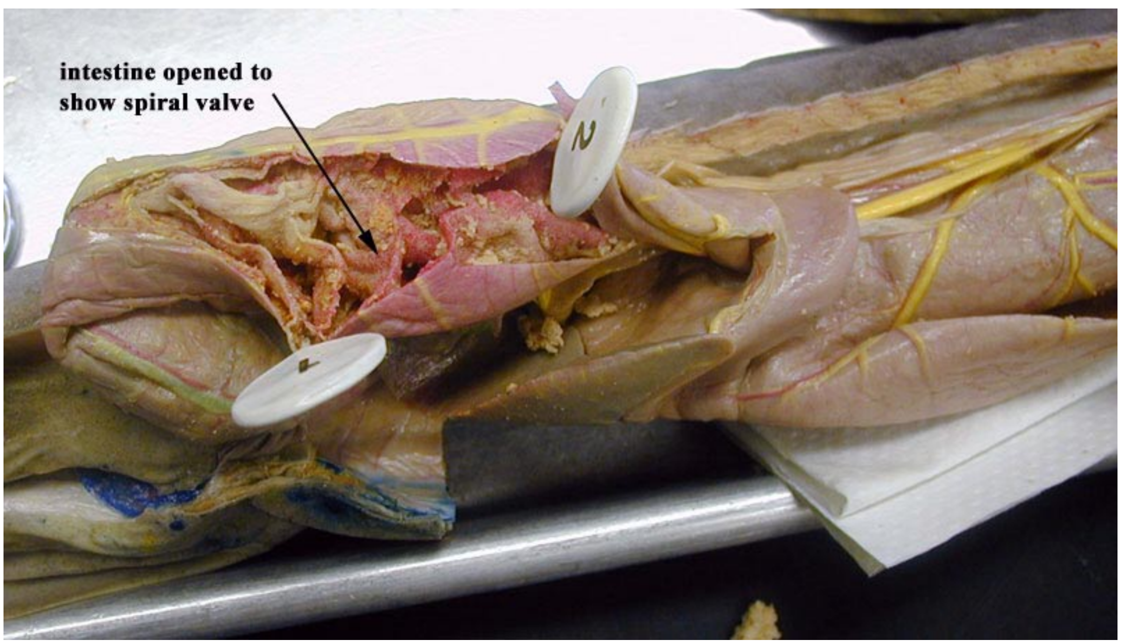

Figure 5 – Internal View of the Valvular Intestine of the Spiny Dogfish Shark

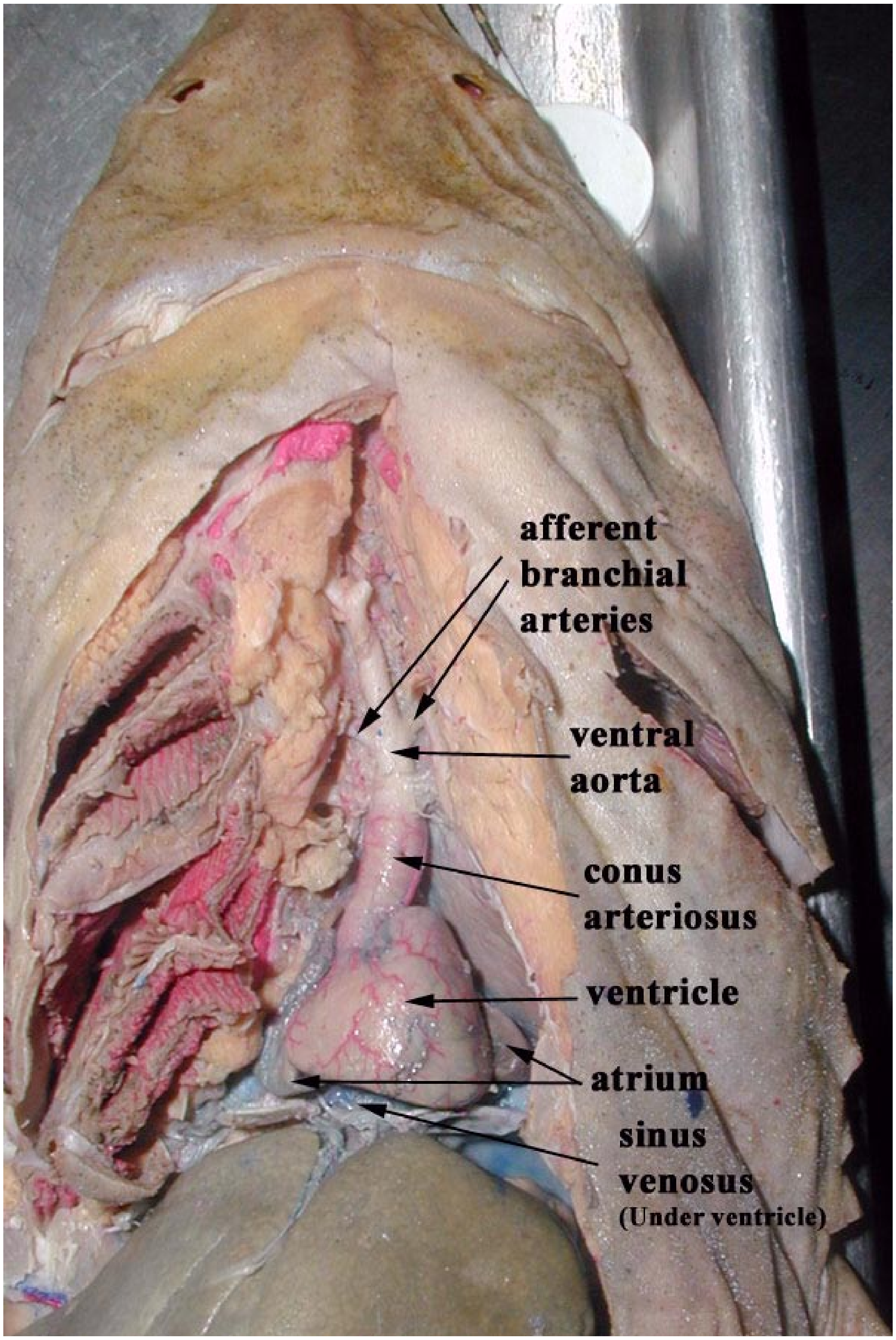

Figure 6 – Heart and Circulatory System Structures of the Spiny Dogfish Shark

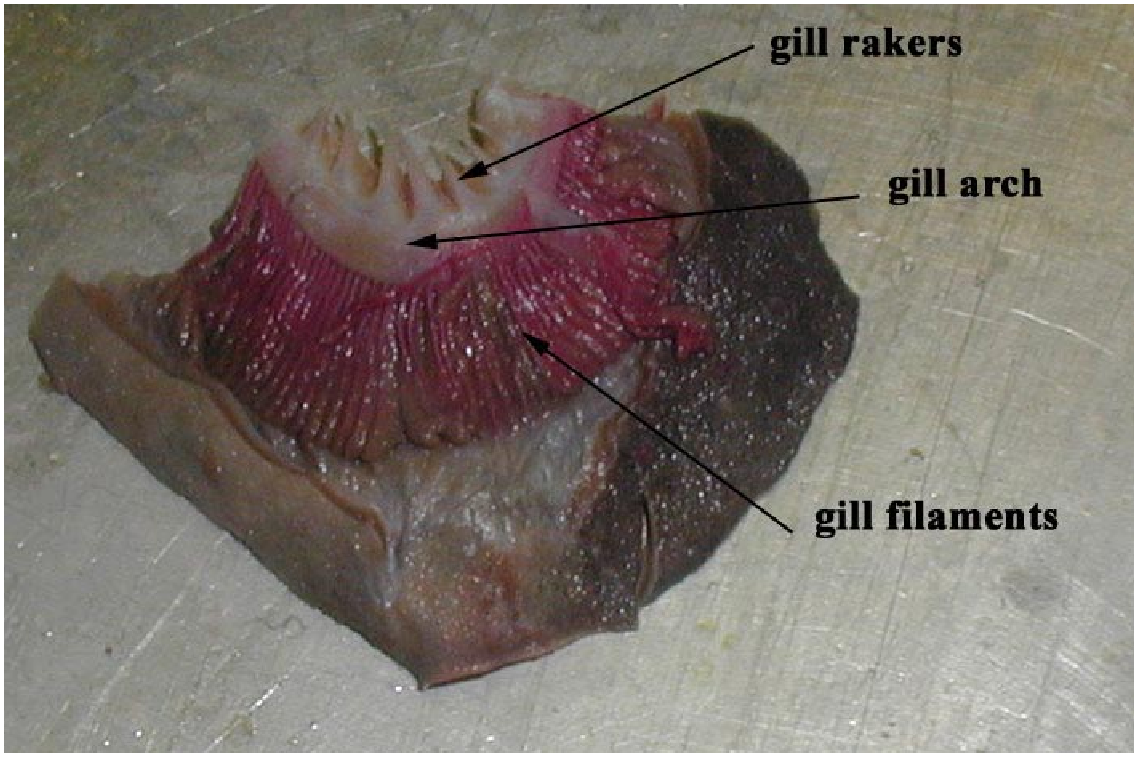

Figure 7 – Gill Structures of the Spiny Dogfish Shark